U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1344

The STRAWBERRY ROOTWORM AS AN ENEMY OF THE GREENHOUSE ROSE

THE STRAWBERRY ROOTWORM or leaf-beetle has, in the last seven or eight years, become a destructive enemy of the greenhouse rose in all the commercial rose-growing districts east of the Rocky Mountains.

The grubs of this insect devour the tender rootlets and girdle the larger roots of the rose plants, while the beetles eat the leaves and succulent bark. In a house that is heavily infested, the beetles in a single night may destroy the "eyes" of all the cut-back plants. Heavy losses due to such injuries have been reported from all the large rose-growing regions except the Pacific coast.

This bulletin describes the strawberry rootworm in the four stages of its development, and gives an outline of measures to be used to control it when it appears in the rose house.

Washington, D. C. July, 1923

THE STRAWBERRY ROOTWORM AS AN ENEMY OF THE GREENHOUSE ROSE.

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CONTENTS.

A NEW ENEMY OF ROSE.

ALTHOUGH the strawberry rootworm [2] or leaf-beetle has achieved much notoriety among florists because of its recent attacks in rose houses, it is doubtful whether all rose growers fully comprehend the destruction which this insect can inflict. During the last 40 years or more it has attained some prominence as an enemy of strawberry and raspberry, and also feeds on apple, peach, black walnut, butternut, and other species. It is a native beetle which occurs out of doors generally throughout the United States, but only in the last seven or eight years has it appeared in the greenhouses. Strangely, in this time it has been found injuring the forced rose plants in widely separated localities, namely, in Missouri, Massachusetts, Indiana, Louisiana, Maryland, Michigan, New Jersey, Pennsylvania, Rhode Island, Virginia, and the District of Columbia. In fact, all the commercial rose-growing districts in the United States east of the Rocky Mountains are affected and have suffered from the invasions of this insect, which the rose grower now finds it necessary to combat relentlessly.

CHARACTER OF INJURY.

Injury is done by the larvæ, or grubs, and by the beetles. Almost every part of the plant above ground is subject to attack by the beetles. The "shot-hole" appearance of the injured leaves (Fig. 1),

[1] The work upon which this bulletin is based was done in cooperation with the Bureau of Plant Industry of the Pennsylvania Department of Agriculture, Prof. J. G. Sanders, Director.

[2] *Paria canella* vars. *quadrinotata* Say and *gilvipes* Crotch. Order Coleoptera, family Chrysomelidae.

which is very characteristic, completely destroys their ornamental value. The beetles also eat the green succulent bark of the forced plants, particularly in crotches, scarring and often girdling the stems. (Fig. 2.) The most serious injury to the plants occurs when they are "cut-back," for at this time the beetles devour the breaking "eyes" in the absence of the foliage. It is on these "eyes" that the florist depends for the development of his future crop, and their destruction means a very serious retardation of the growth and a loss in financial returns. In a single night the beetles in a heavily infested house can eat the heart out of practically every "eye," which means that the plant must spend a period of from six to eight weeks

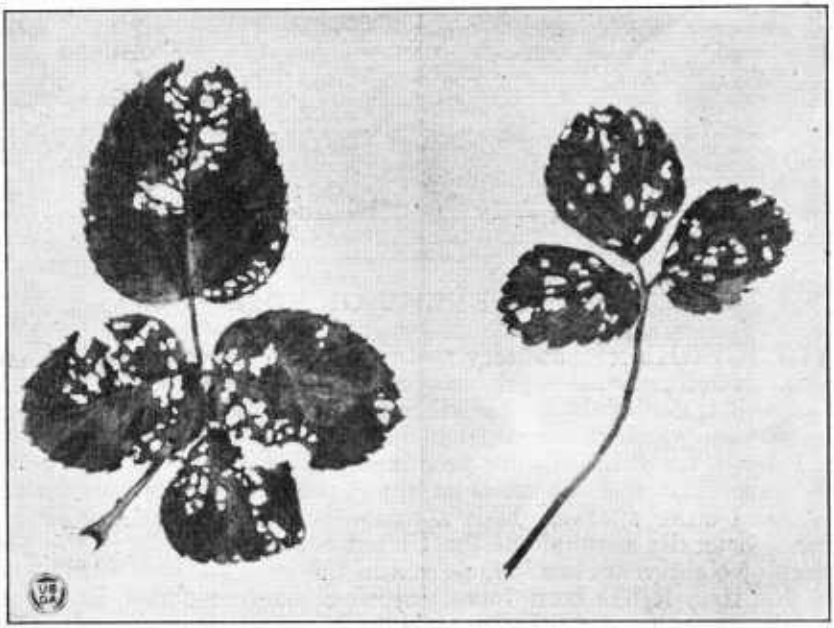


FIG. 1.—Characteristic "shot-hole" feeding punctures made by adults of the strawberry rootworm in foliage of rose and strawberry.

or more in developing a new growth of buds at a time when its vitality should be used in producing new canes and foliage. When present in large numbers the beetles feed upon the flower buds (Fig. 3) and render them unsalable.

The grubs work in a more insidious manner, and their injuries to the plant may escape notice for a long time. Living in the soil as they do, the roots of the plants furnish their food. They not only devour the young tender rootlets but also girdle and gnaw into the stronger ones, even the main roots, thus interfering with the normal functioning of the root system. (Figs. 4 and 5.) The plants become weakened after two or three seasons of the root injury, have a "sickly" appearance, and many fail to respond after the "cutting-back" period. Furthermore, the many wounds in the plants, both on the roots and on the bushes above the ground, furnish just so many places where the microscopic organisms responsible for rose

diseases may find entrance to the plant tissues. Some of these diseases known only too well by the grower are black spot, mildew, crown canker, and crown gall.

ECONOMIC IMPORTANCE.

The vast number of strawberry leaf-beetles which may be present in an infested greenhouse is well illustrated by the experience of one grower who hired several schoolboys to pick the beetles from the plants by hand. For several weeks many thousands of beetles were turned in, as many as 60,000 being collected in one week, the cost of which at 25 cents per 100 beetles amounted to $150. In spite of the destruction of so many beetles, there still seemed to be just as many feeding on the plants. The accounts of another florist showed his gross income per plant in a house of 7,000 plants to be $0.74 for the period from July 1, 1919, to February 1, 1920, as compared with the income of $1.17 for the same period in the preceding year. This decrease of $0.43 per plant,

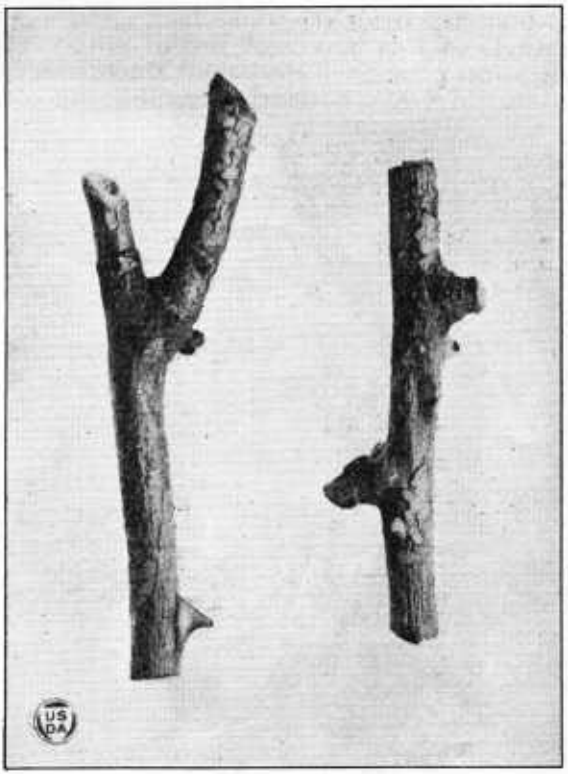


FIG. 2.—Rose stems scarred by the feeding of adults of the strawberry rootworm.

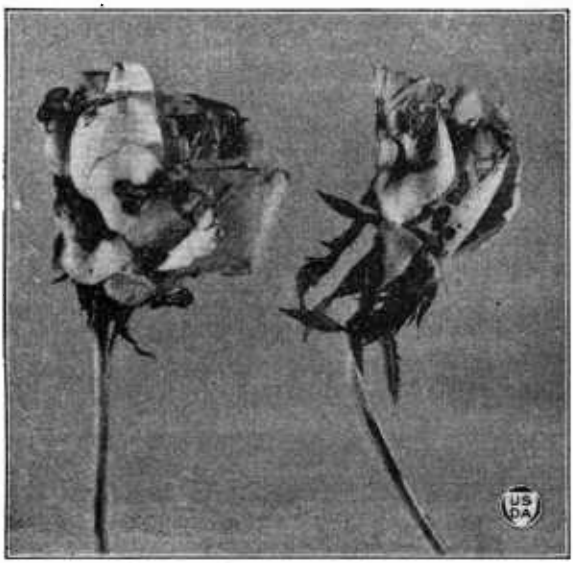


FIG. 3.—Rosebuds ruined by beetles of the strawberry rootworm.

or over $3,000 for the whole house, was due almost entirely to the ravages of this insect. A loss of $70,000 for the year 1920 is the estimate of florists in Bucks and Montgomery Counties, Pa. Similar reports of heavy infestations resulting in severe injury and serious financial loss have been received from all the large rose-growing sections except the Pacific coast region.

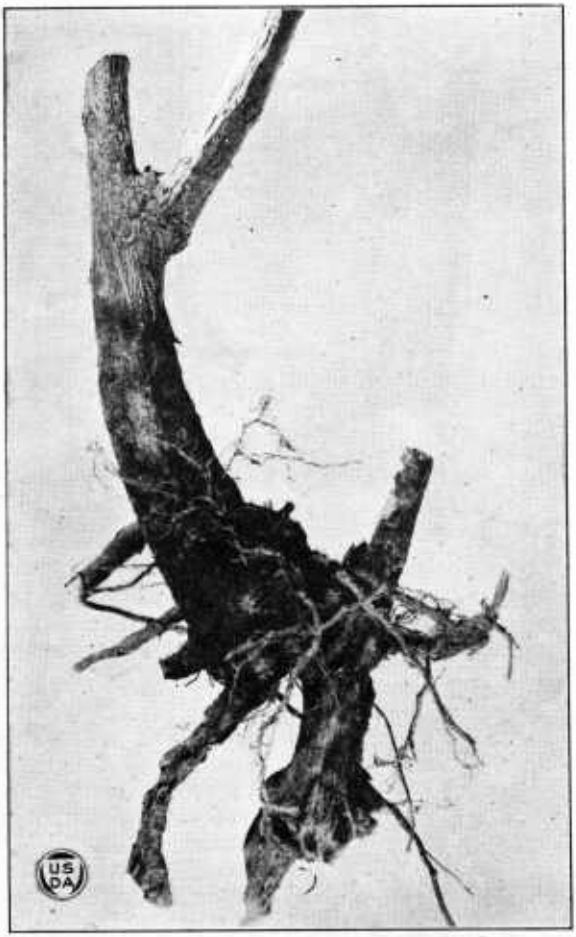


FIG. 4.—Root system of rose plant devoid of rootlets and with main roots severely injured by the feeding of grubs of the strawberry rootworm.

DEVELOPMENT AND HABITS.

There are four distinct and quite different stages (Fig. 5) in the life of the strawberry rootworm, namely, the egg, the larva or grub, the pupa, and the beetle.

THE EGG.

The eggs (Fig. 6), which are about one-thirtieth of an inch long and one-fourth as wide, light cream yellow, and long narrow oval, are laid in groups of from 2 to 10 on dead and dried leaves. The leaves may drop to the ground before the eggs hatch or may be washed from the bushes by syringing. Hatching usually occurs from 7 to 15 days after the eggs are laid, shorter periods occurring during the warmer months.

THE LARVA OR GRUB.

After emerging from the egg, the very tiny larva crawls off (Fig. 5) the leaf and, if the leaf is still on the plant, drops to the ground. With a peculiar spiral-like motion, it immediately burrows into the soil, where, during its development, it feeds upon all parts of the root system. (Figs. 4 and 5.) The larvæ do not come to the surface at any time. The number which may be found around the

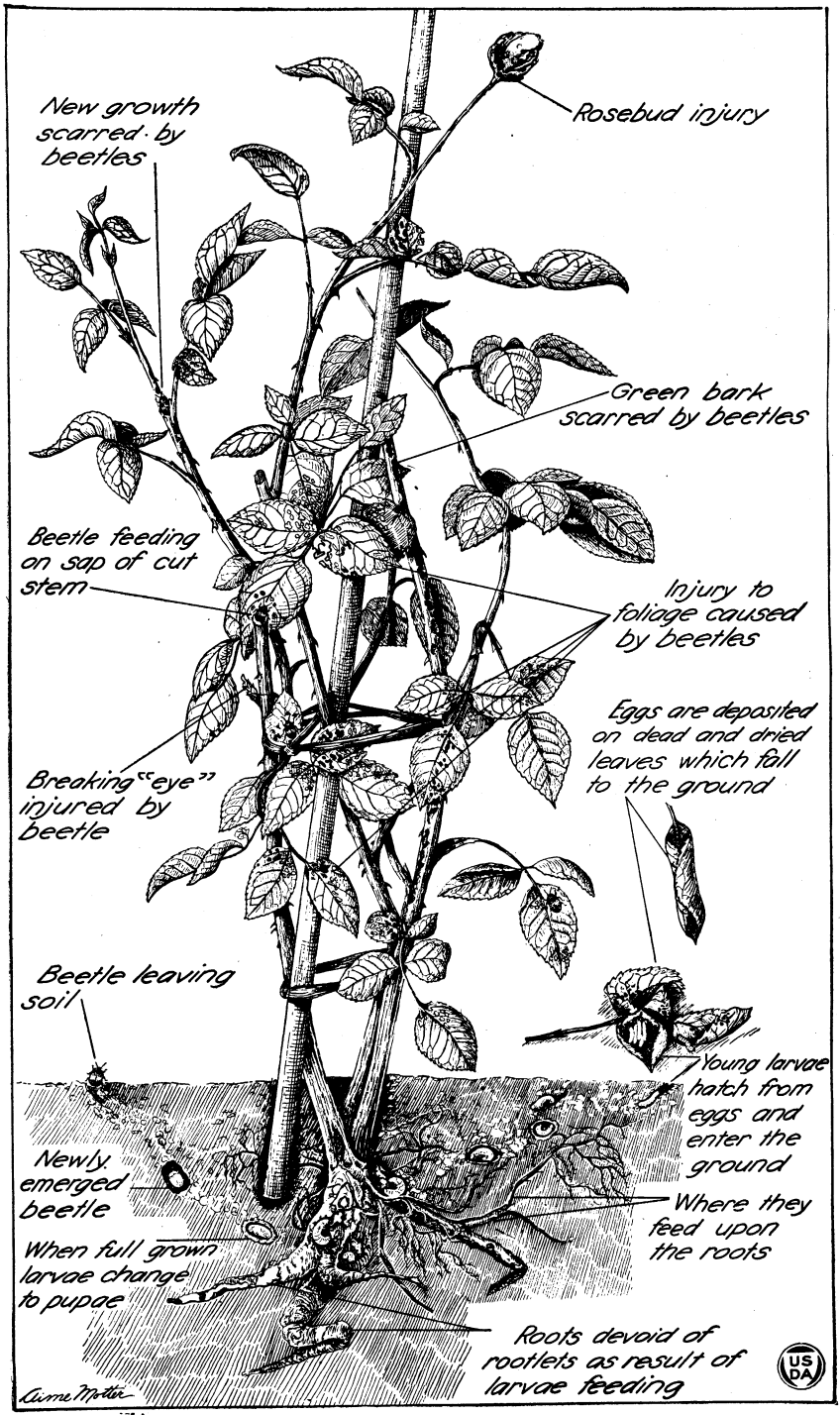


FIG. 5.—Stages in life history of the strawberry rootworm and injury caused by the grubs and beetles.

roots of a single plant is often so astonishing that the observer wonders that the plant is not completely killed in a short time. The average number of larvæ to a plant in a heavily infested house is from 4 to 6 during the late spring and summer months. In several cases 20 or more of the larvæ have been found infesting the roots of an individual rose plant from 5 to 7 years old. The grub becomes full grown (Fig. 7) in from 35 to 60 days, depending on the weather. When full grown it is about one-fifth of an inch long and one-third as wide, resembling very much a small white grub (larva of a May beetle) of that size. The head is light brown and the mandibles, or chewing jaws, are dark brown, while the rest of the body is white and slightly arched.

FIG. 6.—An egg mass of the strawberry rootworm on a portion of dead leaf.

THE PUPA OR RESTING STAGE.

The full-grown larva hollows out a small round cell in a pellet of earth about 2 inches below the surface of the soil, and there changes to the pupa. (Fig. 8.) During this stage the insect is normally very quiet, but when disturbed will wave its abdomen about very actively. The pupa is white, a little shorter than the grub, and bears several long hairs and hooks which prevent the body from coming in direct contact with the walls of its cell. After about 10 days the transformation to the beetle is complete.

THE BEETLE OR ADULT.

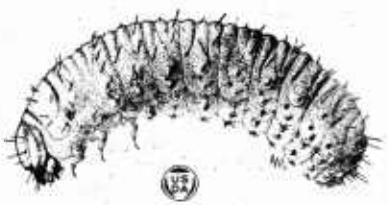


FIG. 7.—The strawberry rootworm larva or grub. Enlarged.

The florist will easily notice the brown shiny beetles (Fig. 9) with four darker brown spots on their backs feeding on the foliage or stems of the plants. The four-spotted form is more common, but occasionally there occur some which are black-bodied, with legs and antennæ, or feelers, of pale yellow, and the reddish head on both varieties will be seen on close examination. The beetle feeds mostly at night or on cloudy days, hiding among the foliage or in the surface mulch during the day. If disturbed it folds up its legs close to the body and drops to the ground, where it plays "possum" for some time. When the insect drops to the ground in this fashion its color blends so well with that of the soil that it is most difficult to find. A puff of tobacco smoke blown on the spot where the beetle dropped will bring it to life quickly, however, and as it moves it will be easily observed.

A female beetle lays eggs during a period of about three months and may deposit as many as 200. There is thus a continuous rearing of progeny, so that no definite broods are apparent. While several individuals have been known to live almost an entire year, the normal life of the beetle is probably about 100 days.

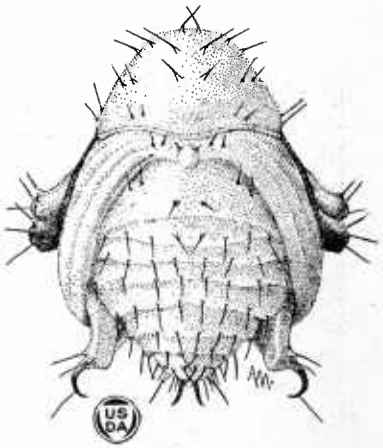


FIG. 8.—Pupa of the strawberry rootworm. Enlarged.

SEASONAL HISTORY.

Many of the adults which emerge in September and October spend the winter hiding in the mulch or soil or in dead leaves, occasionally coming out to feed when the days are clear and warm. After early February they are found on the plant more frequently, and the females begin laying eggs the latter part of February, continuing to do so through March and April. A few beetles continue to lay eggs during May and June as well. The individuals which develop from these eggs begin to appear in May and are present in large numbers during June and July. During the latter two months many eggs are laid, and the full-grown beetles which develop from them appear in September and October and live through the winter.

FIG. 9.—Beetle of the four-spotted variety of the strawberry rootworm. Enlarged.

HOW TO CONTROL THE PEST.

The methods ordinarily used to combat leaf-feeding insects out of doors have been found by both florists and entomologists to be unsatisfactory in checking the ravages of this pest in the greenhouse. Just as the culture of the rose in greenhouses is much more intensive than ordinary agricultural methods out of doors, the control measures must be highly specialized and very much more thorough than when used against common pests. The florists, therefore, can not rely on any one method alone to reduce materially an infestation of the strawberry rootworm, but must wage relentless warfare with all available means. Those recommendations for control which have been adopted are best suited to the florists' cultural methods and

are aimed at the vulnerable points in the life history and habits of the insect. Success in controlling infestations will depend very largely upon the thoroughness and persistence of the treatments.

HYDROCYANIC-ACID GAS FUMIGATION.

The most efficient manner of killing the adults is by the use of hydrocyanic-acid gas. Used at the rate of 1½ to 2 ounces of sodium cyanid to each 1,000 cubic feet of space, the gas will kill practically every beetle above the ground. At this strength the gas also will injure the tender growth of roses and, therefore, can be utilized in the drying-off period only. Since the beetles are most numerous

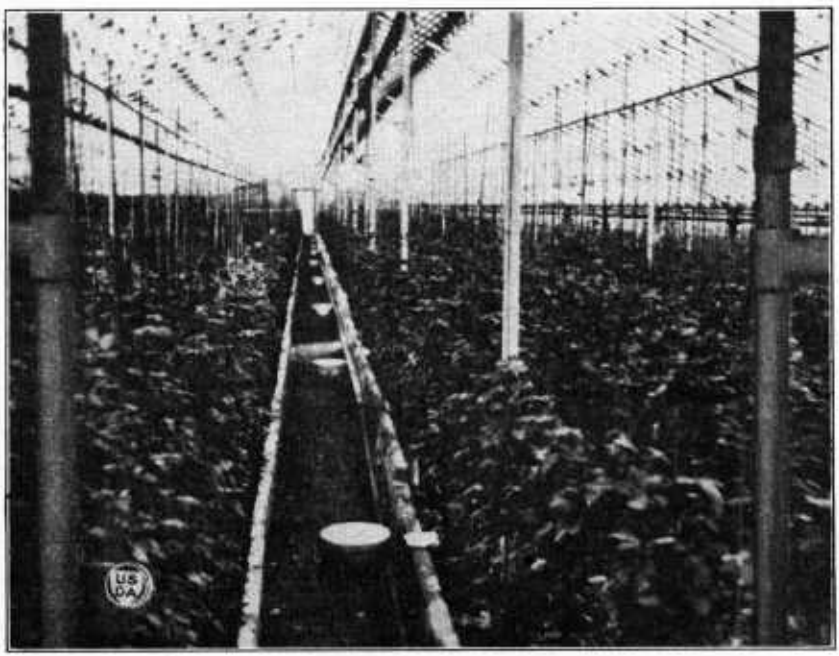


FIG. 10.—Greenhouse prepared for fumigation with hydrocyanic-acid gas.

during the summer, when the florists rest their plants, it is seen that this is really the most favorable time for hydrocyanic-acid gas fumigation, as the control operation readily fits in with the cultural practice.

Before the plants are cut back they should be subjected to three or more successive fumigations at intervals of three or four days, and the last exposure should take place the night preceding the cutting back. The materials to be used for every 1,000 cubic feet of space in the greenhouse are as follows:

Sodium cyan'd	ounces (avoirdupois)	1½ to 2
Sulphuric acid	ounces (fluid)	2¼ to 3
Water	do	4½ to 6

For each ounce avoirdupois of sodium cyanid (containing approximately 51 per cent cyanogen), 1½ fluid ounces of sulphuric acid (1.83 specific gravity), and 3 fluid ounces of water have been used

by the writers. This is a slight divergence from the formula generally accepted, owing to the necessity of securing sufficient dilute acid to submerge the cyanid. Under greenhouse conditions it is necessary to use a number of generators in order to secure an equal distribution of the gas, and as this number is increased the amount of chemicals in each generator is proportionately decreased, which will result in poor generation unless there is a slight excess of water. If it were possible to have a number of small generators considerably constricted inside at the bottom it would be possible to get a satisfactory generation of the gas with the usual 1–1½–2 formula.

To obtain the most successful results, the fumigating must be done *at night* and the greenhouse must be kept closed for two hours.

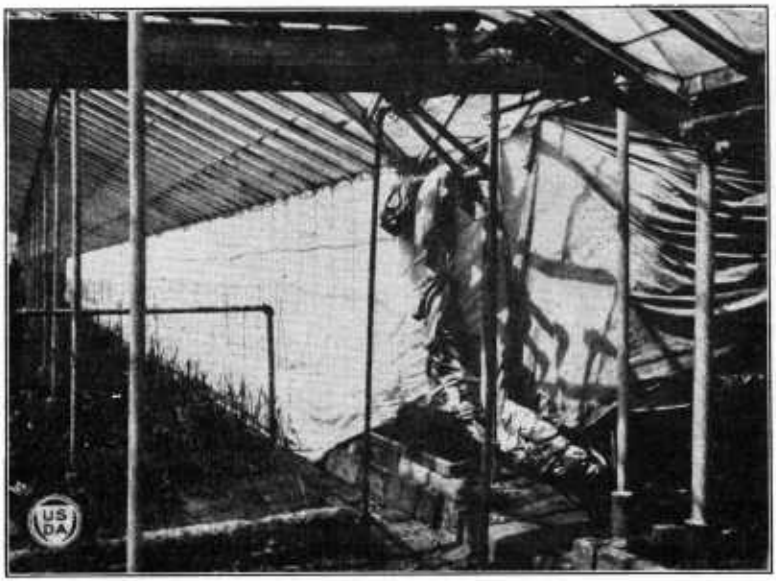


FIG. 11.—Muslin curtains used to separate sections of an open range of greenhouses during fumigation with hydrocyanic-acid gas.

(Fig. 10.) Under these conditions no regard need be had for the temperature. Practically every adult above ground will be found dead the following morning. It is again emphasized that roses can be safely fumigated during the resting period at the rate of 2 ounces of sodium cyanid per 1,000 cubic feet of space, whereas in the forcing period one-half ounce may cause considerable injury under unfavorable conditions. Therefore at the 2-ounce strength the gas can not be used in a house where plants are being forced, unless the grower is willing to accept the injury that will result. It is strongly recommended that houses be given the "drying" treatment as a whole and not in sections. Any portion of an open range of houses may be satisfactorily separated by the use of canvas or muslin curtains (Figs. 11 and 12) or oiled paper, thus solving a serious problem of the past in construction of this type. Further directions for fumigating greenhouses with hydrocyanic-acid gas are given in Farmers' Bulletin 880.

SCRAPING SOIL OF BEDS.

Immediately after the tops are cut from the plants and removed, the dry surface layer of soil to a depth of 1 or 2 inches should be carefully scraped from the beds and taken a safe distance away from the greenhouses. This layer of soil contains many adults, and the shaking of the tops when they are being cut causes many others to drop and hide in it until night. To be effective the scraping must be done the same day that the tops are cut off, otherwise the beetles will come out of hiding in the evening and when they find no foliage left to eat will devour the "eyes" and girdle the stems. The florist may replace the soil according to his own cultural methods. Preferably the plants should be given their first heavy watering before the new soil is brought in, and well composted soil should be used.

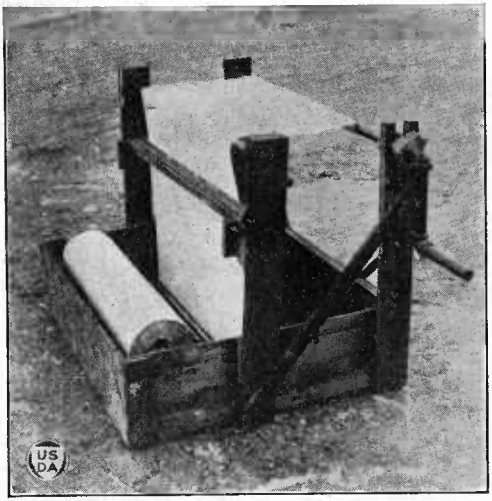


FIG. 12.—Method of preparing oiled paper which may be used instead of muslin to separate sections of an open range of greenhouses during fumigation with hydrocyanic-acid gas.

SPRAYING WITH ARSENICALS.

Immediately after the plants are cut back, the tops carried away, and the surface layer of soil removed, the plants should be sprayed with either lead arsenate or calcium arsenate. This also should be done the same day that the plants are cut back, so that any beetles coming from hiding places will find every portion of the plant protected. The arsenical should be mixed in the following proportions:

Lead arsenate or calcium arsenate (dry)	pounds	4
Water	gallons	50
Soap (for sticker)	pounds	2

The stems should be sprayed so thoroughly with the solution that all portions are covered completely and should present a whitewashed appearance. The spray may be mixed in a large tub or tank and applied by means of compressed-air sprayers.

TREATMENT WITH KEROSENE NICOTINE OLEATE.[2]

During the last few years a new contact insecticide has been developed by the formation of a soap or soaplike salt by the union of nicotine and commercial oleic acid (red oil), which when combined is known as nicotine oleate. It may be prepared from any nicotine preparation containing free nicotine. It dissolves in soft water,

[2] Moore, William. A promising new contact insecticide. Journal of Economic Entomology, volume 11, No. 3, pp. 341, 342. June, 1918.

forming a soapy solution, which may be used to emulsify an animal, vegetable, or mineral oil.

When the plants are watered heavily a brief syringing of the foliage knocks the beetles from the bushes into the pools and puddles of surface water. Filming the surface of these pools with kerosene nicotine oleate will kill the beetles as they swim through it. This material is mixed as follows:

STOCK EMULSION.

Solution 1:	
Kerosene	8 parts or 1 gallon.
Oleic acid	1 part or 1 pint.
Solution 2:	
Volatile or free nicotine, 40 per cent solution	2 parts or 2 pints.
Water	8 parts or 1 gallon.

Solution 1 is prepared by slowly pouring the oleic acid into the kerosene, stirring constantly. In another vessel make up Solution 2 by adding the nicotine solution to the water. The stock emulsion is then prepared by stirring Solution 1 into Solution 2, and the mixture is brought to a creamy consistency by rapidly churning it for several minutes, pouring from one vessel to the other or pumping the liquid back upon itself through a bucket pump.

Use 1 pint of the stock emulsion to 4 gallons of water and apply to the flooded beds by means of a sprinkling can, so that a film of the material covers the whole surface of the water. Those periods when the beetles are numerous, particularly September and October, are the favorable times for successful use of this treatment.

DUSTING WITH ARSENICALS.

After the middle of February, when the beetles begin to appear and are wont to feed upon the foliage, a coating of an arsenical should be maintained over the whole plant. Since the adults are present and feed at all times during the spring and summer until about November, continual applications of these materials during this period are necessary. The mixture used should contain at least 10 per cent of either lead arsenate or calcium arsenate, and preferably 15 per cent. The following formulæ are recommended. The florist may purchase them ready prepared or he may mix them himself.

Formula 1:		
Superfine sulphur (200 mesh)	pounds	90
Lead arsenate or calcium arsenate	do	10
Formula 2:		
Superfine sulphur (200 mesh)	do	85
Lead arsenate or calcium arsenate	do	15

When applied by means of the improved hand dusters of either the fan type (Fig. 13) or the bellows type (Fig. 14) now on the market, 8 pounds of the dust will cover the foliage and stems of 3,000 plants 2 or 3 feet tall. This number of plants can be dusted in from five to eight minutes.

The florist will find this material very easy to apply, and as it readily washes off the foliage it will not impair the value of the cut

flowers. Because it washes off the foliage, it is necessary to dust the plants after every syringing, in order to maintain the coating of poison. This frequency of application, however, will keep all the new growth well covered and protected from the ravages of the beetles. Also the sulphur in the mixture will be of considerable value in keeping in check such leaf diseases as mildew and black spot.

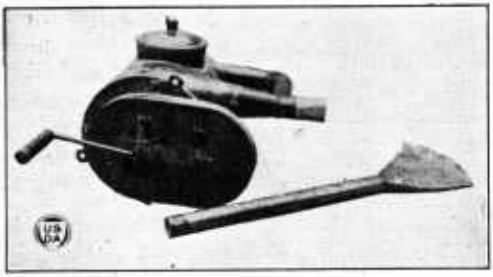


FIG. 13.—Fan type of hand duster used in applying insecticidal dusts in greenhouses.

TREATING WITH TOBACCO DUST AND WOOD ASHES.

The value of tobacco dust and wood ashes as fertilizers has long been recognized by florists, but there is some insecticidal effect as well in both. Experiments have shown that the newly hatched larvæ of the strawberry rootworm are killed when they come in contact with tobacco dust. As the larvæ are hatching almost continuously from March to September, the surface of the beds should be kept covered with this material to prevent the larvæ from entering the soil. Applications every two weeks will be sufficient if the dust is carefully spread over the entire surface. It must not be forgotten that a bare spot permits an entrance to the soil for the little grubs. Tobacco dust containing not less than one-half of 1 per cent nicotine should be used. The rose plant can not stand a very heavy application of wood ashes, and a handful of this material to each plant every two or three weeks will suffice. The continuous leaching of tobacco dust and wood ashes will help in reducing an infestation by destroying many of the larvæ and pupa in the soil.

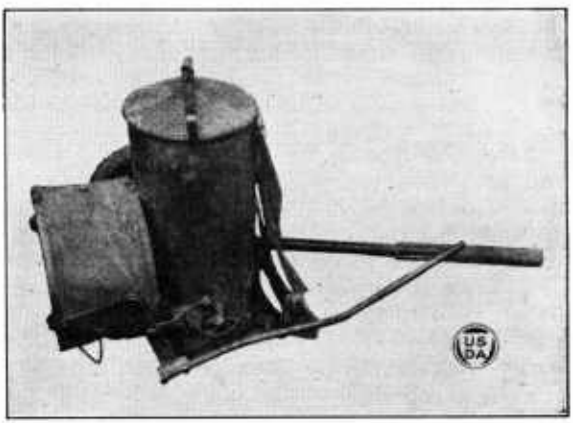


FIG. 14.—Bellows type of hand duster used in applying insecticidal dusts in greenhouses.

CLEAN CULTURE AND HAND PICKING.

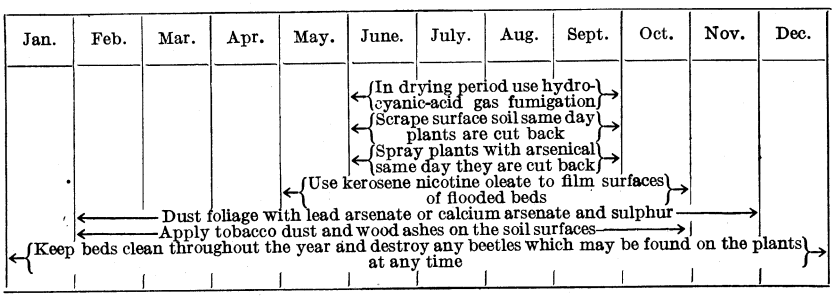
The florist should at all times keep the beds free from dead leaves and other débris, which furnish hiding places for the strawberry rootworm adults and in which many eggs are laid. All such material removed during the winter months will carry away a con-

siderable number of beetles and, therefore, will preclude their laying eggs in the spring. From February to September the removal of all dead leaves every 10 days at most will prevent access to the soil of any larvæ which may hatch from eggs in the leaves. When the beetles are very numerous in a greenhouse, the florist should forego any mulching with manure and feed the plants with manure water instead. Working among the plants every day, caring for the individual needs of each plant, the grower soon acquires the habit of killing every beetle he encounters on the leaves, buds, stakes, or wires, and persistent destruction in this manner will help materially in reducing infestations. As many beetles as possible should be destroyed during the fall and early spring, to reduce the number of overwintering beetles which lay eggs from February to June.

CONTROL PROGRAM.

In the accompanying chart the various recommendations for control are entered according to the periods when each may be successfully applied. As previously stated, reliance can not be placed on one method alone, and the florist must adopt every measure which he can fit into his cultural program.

CONTROL MEASURES FOR STRAWBERRY ROOTWORM AND WHEN THEY SHOULD BE FOLLOWED.



The following program combining both cultural and control methods is recommended:

Keep the beds free from dead leaves, weeds, and other trash at all times.

After each syringing, beginning about February 15, dust the plants with a dry mixture consisting of 15 parts of lead arsenate or calcium arsenate and 85 parts of sulphur. Continue this treatment until the plants are cut back.

Keep the bed surface covered with tobacco dust from the middle of February until the drying period and apply wood ashes about once a month as recommended.

During the drying period fumigate three or more times with hydrocyanic-acid gas, the last fumigation to be given the night before the plants are cut back.

Follow the workers who are cutting away the tops with another group to scrape the soil from the surface.

After cleaning out all the tops and after scraping the soil, spray the stalks with lead arsenate or calcium arsenate to protect the bark and "eyes."

Water the beds the day after cutting back and replace the removed soil with new.

As the new growth begins to develop keep it dusted continuously to prevent feeding by beetles.

During September and October keep the plants very thoroughly dusted with arsenicals, because during these months the beetles are emerging and feeding voraciously and the chances of poisoning them at this time are very good.

During these two months apply two or three kerosene nicotine oleate treatments at times when the beds are watered heavily.

PREVENTIVE MEASURES.

The grower who wishes to keep the strawberry rootworm out of his greenhouses will find it necessary to employ several precautionary measures. It is best to obtain soil from fields where there have been no strawberry plants, and this soil should be composted for several months before it is placed in the beds, or else it should be sterilized before using, in order to destroy any of the forms which may be present. Young plants while being propagated are not ordinarily infested, but they should be grown in separate houses free from these insects, and under no conditions is it advisable to keep the young stock in proximity to any infested beds or houses, because of the danger of becoming contaminated. The grower who buys his plants should assure himself that the propagator has used every care to keep the young stock protected from possible infestation.

Florists should keep their greenhouses as clean as possible, removing dead leaves and other débris from the beds, keeping the walks swept, and all nooks and corners free from rubbish. All such material should be removed to a considerable distance from the greenhouse and burned, to preclude the return of any injurious pests which might be thus carried out. The same treatment should be accorded the tops of the bushes which are removed at "cutting back." The importance of these preventive measures is too frequently underestimated by many growers, but scientific evidence and practical results prove that due consideration must be accorded such means of preventing insects from gaining a foothold in the greenhouse.

Plants that have been in beds for three or more years are usually the more heavily infested, and the chances of severe infestation are very much reduced by removing plants and soil at the end of three years at the latest. A rotation should be followed whereby no section of plants will remain in the houses more than three years. For example, if a range of several houses has solid partitions, dividing the place into four separate sections—A, B, C, and D—A and D should be completely cleaned out and replanted one season, B should be handled the next season, and C the third season. At the fourth season the plants in A and D, which would be 3 years old, are replaced, and so on. In this way no plants are retained for more than three years. During the last few years several florists have forced their plants as much as possible for three years rather than try to save them for longer periods of production, claiming that the increase of production by this method more than compensates any extra expense occasioned by the more frequent replanting

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